

1     WHAT IS CLAIMED IS:

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3     1.     A method of processing information represented by an original series of (run,  
4     level) pairs, said method comprising:

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6             a) inspecting the (run, level) pairs in the original series of (run, level) pairs to  
7     determine whether or not modification of at least one (run, level) pair in the original  
8     series of (run, level) pairs would produce a desirable decrease in a number of bits  
9     required for variable-length encoding of said information despite introduction of noise  
10    into the variable-length encoding of said information; and

11

12             b) upon determining that modification of said at least one (run, level) pair in the  
13     original series of (run, level) pairs would produce a desirable decrease in the number of  
14     bits required for variable-length encoding of said information despite introduction of  
15     noise into the variable-length encoding of said information, modifying said at least one  
16     (run, level) pair to produce a modified series of (run, level) pairs from the original series  
17     of (run, level) pairs; and

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19             c) variable-length encoding the modified series of (run, level) pairs.

20

21     2.     The method as claimed in claim 1, which is performed by sequentially inspecting  
22     each (run, level) pair to determine whether or not modification of said each (run, level)  
23     pair would produce a desirable decrease in the number of bits required for variable-length

1 encoding of said information despite introduction of noise into the variable-length  
2 encoding of said information; and if modification of said each (run, level) pair would  
3 produce a desirable decrease in the number of bits required for variable-length encoding  
4 of said information despite introduction of noise into the variable-length encoding of said  
5 information, then modifying said each (run, level) pair; and then variable-length encoding  
6 said each (run, level) pair.

7

8 3. The method as claimed in claim 1, wherein the inspecting the (run, level) pairs in  
9 the original series of (run, level) pairs includes lookup of a table specifying whether or  
10 not certain (run, level) pairs should be modified.

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12 4. The method as claimed in claim 1, wherein the inspecting the (run, level) pairs in  
13 the original series of (run, level) pairs includes testing for certain ranges of run lengths  
14 and level values to determine whether or not certain (run, level) pairs should be modified.

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16 5. The method as claimed in claim 1, wherein said at least one (run, level) pair has a  
17 run length of M that is greater than zero and a level value of N, and the production of the  
18 modified series of (run, level) pairs from the original series of (run, level) pairs includes  
19 substituting, for said at least one (run, level) pair, a first (run, level) pair immediately  
20 followed by a second (run, level) pair, the first (run, level) pair having a run length of M-  
21 1 and a level having a minimum non-zero magnitude, the second (run, level) pair having  
22 a run length of zero and a level value of N.

23

1 6. The method as claimed in claim 5, which includes decoding the variable-length  
2 encoding of the modified series of (run, level) pairs to produce a decoded series of (run,  
3 level) pairs, and inspecting the (run, level) pairs in the decoded series of (run, level) pairs  
4 to find the first (run, level) pair having a minimum non-zero magnitude immediately  
5 followed by the second (run, level) pair having a run length of zero, and determining that  
6 the first (run, level) pair is likely to be noise introduced during the production of the  
7 modified series of (run, level) pairs from the original series of (run, level) pairs and  
8 therefore rejecting the first (run, level) pair.

9  
10 7. The method as claimed in claim 6, which includes a table lookup for determining  
11 that the first (run, level) pair is likely to be noise introduced during the production of the  
12 modified series of (run, level) pairs from the original series of (run, level) pairs.

13  
14 8. The method as claimed in claim 1, which includes decoding the variable-length  
15 encoding of the modified series of (run, level) pairs to produce a decoded series of (run,  
16 level) pairs, and inspecting the (run, level) pairs in the decoded series of (run, level) pairs  
17 to find (run, level) pairs likely to be noise introduced during the production of the  
18 modified series of (run, level) pairs from the original series of (run, level) pairs and  
19 therefore rejecting the (run, level) pairs likely to be noise introduced during the  
20 production of the modified series of (run, level) pairs from the original series of (run,  
21 level) pairs.

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1        9.     A method of variable-length encoding a block of pixels, the method comprising:

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3            a) computing a two-dimensional discrete cosine transform (DCT) of the block of

4        pixels to produce a series of DCT coefficient values;

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6            b) quantizing the DCT coefficient values to produce quantized coefficient values;

7

8            c) producing an original series of (run, level) pairs each having a level value

9        indicating a respective non-zero quantized coefficient value;

10

11            d) inspecting the (run, level) pairs in the original series of (run, level) pairs to

12        determine whether or not modification of at least one (run, level) pair in the original

13        series of (run, level) pairs would produce a desirable decrease in a number of bits

14        required for variable-length encoding of said block of pixels despite introduction of noise

15        into the variable-length encoding of said block of pixels; and

16

17            e) upon determining that modification of said at least one (run, level) pair in the

18        original series of (run, level) pairs would produce a desirable decrease in the number of

19        bits required for variable-length encoding of said block of pixels despite introduction of

20        noise into the variable-length encoding of said block of pixels, modifying said at least

21        one (run, level) pair to produce a modified series of (run, level) pairs from the original

22        series of (run, level) pairs; and

23

1 f) variable-length encoding the modified series of (run, level) pairs.

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3 10. The method as claimed in claim 9, which is performed by sequentially inspecting  
4 each (run, level) pair to determine whether or not modification of said each (run, level)  
5 pair would produce a desirable decrease in the number of bits required for variable-length  
6 encoding of said block of pixels despite introduction of noise into the variable-length  
7 encoding of said block of pixels; and if modification of said each (run, level) pair would  
8 produce a desirable decrease in the number of bits required for variable-length encoding  
9 of said block of pixels despite introduction of noise into the variable-length encoding of  
10 said block of pixels, then modifying said each (run, level) pair; and then variable-length  
11 encoding said each (run, level) pair.

12

13 11. The method as claimed in claim 9, wherein the inspecting of the (run, level) pairs  
14 in the original series of (run, level) pairs includes lookup of a table specifying whether or  
15 not certain (run, level) pairs should be modified.

16

17 12. The method as claimed in claim 9, wherein the inspecting of the (run, level) pairs  
18 in the original series of (run, level) pairs includes testing for certain ranges of run lengths  
19 and level values to determine whether or not certain (run, level) pairs should be modified.

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21 13. The method as claimed in claim 9, wherein said at least one (run, level) pair has a  
22 run length of M that is greater than zero and a level value of N, and the production of the  
23 modified series of (run, level) pairs from the original series of (run, level) pairs includes

1 substituting, for said at least one (run, level) pair, a first (run, level) pair immediately  
2 followed by a second (run, level) pair, the first (run, level) pair having a run length of M-  
3 1 and a level having a minimum non-zero magnitude, and the second (run, level) pair  
4 having a run length of zero and a level value of N.

5

6 14. The method as claimed in claim 9, wherein the production of the original series of  
7 (run, level) pairs from the quantized DCT coefficient values includes identifying some  
8 DCT coefficients having non-zero values that are less significant than values of other  
9 DCT coefficients, the original series of (run, level) pairs does not include (run, level)  
10 pairs encoding level values for said some DCT coefficients, said first (run, level) pair  
11 specifies a level value for one of said some DCT coefficients, said one of said some DCT  
12 coefficients has a sign, and the level value of said first (run, level) pair is selected to have  
13 the same sign as the sign of said one of said some DCT coefficients.

14

15 15. The method as claimed in claim 9, wherein the production of the original series of  
16 (run, level) pairs from the quantized DCT coefficient values includes identifying some  
17 DCT coefficients having non-zero values that are less significant than values of other  
18 DCT coefficients, the original series of (run, level) pairs does not include (run, level)  
19 pairs encoding level values for said some DCT coefficients, and the method includes  
20 modifying at least one (run, level) pair in order to reduce noise without increasing the  
21 number of bits for the variable-length encoding by including in the modified series a (run,  
22 level) pair encoding a minimum magnitude level for at least one of said some DCT  
23 coefficients, said at least one of said some DCT coefficients has a sign, and the (run,

1 level) pair encoding a minimum magnitude level for said at least one of said some DCT  
2 coefficients has a sign equal to the sign of the said at least one of said some DCT  
3 coefficients.

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5 16. A method of producing MPEG encoded video from an original series of MPEG-  
6 compliant (run, level) pairs, said method comprising:

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8 a) inspecting the (run, level) pairs in the original series of (run, level) pairs to  
9 determine whether or not modification of at least one (run, level) pair in the original  
10 series of (run, level) pairs would produce a desirable decrease in a number of bits in the  
11 MPEG encoded video despite introduction of noise into the MPEG encoded video; and

12

13 b) upon determining that modification of said at least one (run, level) pair in the  
14 original series of (run, level) pairs would produce a desirable decrease in the number of  
15 bits in the MPEG encoded video despite introduction of noise into the MPEG encoded  
16 video, replacing said at least one (run, level) pair with a sequence of a first (run, level)  
17 pair and a second (run, level) pair to produce a modified series of (run, level) pairs from  
18 the original series of (run, level) pairs, said at least one (run, level) pair having a non-zero  
19 run length of M and a non-zero level value of N, the first (run, level) pair having a run  
20 length of M-1 and a level magnitude of one, and the second (run, level) pair having a run  
21 length of zero and a level value of N; and

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1 c) variable-length encoding the modified series of (run, level) pairs to produce the  
2 MPEG encoded video.

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5 17. The method as claimed in claim 16, which includes sequentially inspecting each  
6 (run, level) pair in the original series of MPEG-compliant (run, level) pairs to determine  
7 whether or not modification of said each (run, level) pair would produce a desirable  
8 decrease in the number of bits in the MPEG encoded video despite introduction of noise  
9 into the MPEG encoded video; and if modification of said each (run, level) pair would  
10 produce a desirable decrease in the number of bits required in the MPEG encoded video  
11 despite introduction of noise into the MPEG encoded video, then modifying said each  
12 (run, level) pair; and then variable-length encoding said each (run, level) pair.

13

14 18. The method as claimed in claim 16, wherein the inspecting of the (run, level)  
15 pairs in the original series of MPEG-compliant (run, level) pairs includes lookup of a  
16 table specifying whether or not certain (run, level) pairs should be modified.

17

18 19. The method as claimed in claim 16, wherein the inspecting of the (run, level)  
19 pairs in the original series of (run, level) pairs includes testing for certain ranges of run  
20 lengths and level values to determine whether or not certain (run, level) pairs should be  
21 modified.

22

1 20. A method of decoding MPEG encoded video that includes noise introduced  
2 during the encoding process by insertion of at least one (run, level) pair having a level  
3 magnitude of one, said method comprising;

4 a) decoding a series of (run, level) pairs from the MPEG encoded video; and  
5 b) inspecting the series of (run, level) pairs to find said at least one (run, level)  
6 pair having a level magnitude of one; and

7 c) determining that said at least one (run, level) pair having a level magnitude of  
8 one is likely to represent noise introduced during the encoding process, and therefore  
9 rejecting said at least one (run, level) pair having a level magnitude of one in order to  
10 reduce noise.

11

12 21. The method as claimed in claim 20, which includes a table lookup using the run  
13 length of said at least one (run, level) pair having a level magnitude of one and a level  
14 magnitude of a (run, level) pair immediately following said at least one (run, level) pair  
15 having a level magnitude of one for determining that said at least one (run, level) pair  
16 having a level magnitude of one is likely to represent noise introduced during the  
17 encoding process.

18

19 22. The method as claimed in claim 20, wherein the noise is introduced during the  
20 encoding process by insertion of (run, level) pairs having a predetermined level value  
21 having a magnitude of one, and the decoding process does not reject (run, level) pairs  
22 having a level value different from the predetermined level value.

23

1       23.    A digital computer for producing MPEG encoded video from an original series of  
2       MPEG-compliant (run, level) pairs, said digital computer comprising at least one  
3       processor programmed for:

4

5           a) inspecting the (run, level) pairs in the original series of (run, level) pairs to  
6       determine whether or not modification of at least one (run, level) pair in the original  
7       series of (run, level) pairs would produce a desirable decrease in a number of bits in the  
8       MPEG encoded video despite introduction of noise into the MPEG encoded video; and

9

10          b) upon determining that modification of said at least one (run, level) pair in the  
11       original series of (run, level) pairs would produce a desirable decrease in the number of  
12       bits in the MPEG encoded video despite introduction of noise into the MPEG encoded  
13       video, replacing said at least one (run, level) pair with a sequence of a first (run, level)  
14       pair and a second (run, level) pair to produce a modified series of (run, level) pairs from  
15       the original series of (run, level) pairs, said at least one (run, level) pair having a non-zero  
16       run length of M and a non-zero level value of N, the first (run, level) pair having a run  
17       length of M-1 and a level magnitude of one, and the second (run, level) pair having a run  
18       length of zero and a level value of N; and

19

20          c) variable-length encoding the modified series of (run, level) pairs to produce the  
21       MPEG encoded video.

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1 24. The digital computer as claimed in claim 23, wherein said at least one processor is  
2 programmed for sequentially inspecting each (run, level) pair in the original series of  
3 MPEG-compliant (run, level) pairs to determine whether or not modification of said each  
4 (run, level) pair would produce a desirable decrease in the number of bits required in the  
5 MPEG encoded video despite introduction of noise into the MPEG encoded video; and if  
6 modification of said each (run, level) pair would produce a desirable decrease in the  
7 number of bits required for variable-length encoding of the MPEG encoded video despite  
8 introduction of noise into the MPEG encoded video, then modifying said each (run, level)  
9 pair; and then variable-length encoding said each (run, level) pair.

10

11 25. The digital computer as claimed in claim 23, wherein said at least one processor is  
12 programmed for lookup of a table specifying whether or not certain (run, level) pairs  
13 should be modified.

14

15 26. The digital computer as claimed in claim 23, wherein said at least one processor is  
16 programmed for testing for certain ranges of run lengths and level values to determine  
17 whether or not certain (run, level) pairs should be modified.

18

19 27. A decoder for decoding MPEG encoded video that includes noise introduced  
20 during the encoding process by insertion of at least one (run, level) pair having a level  
21 magnitude of one, the decoder comprising at least one processor programmed for:

22 a) decoding a series of (run, level) pairs from the MPEG encoded video; and

1                   b) inspecting the (run, level) pairs to find said at least one (run, level) pair having  
2                   a level magnitude of one; and

3                   c) determining that said at least one (run, level) pair having a level magnitude of  
4                   one is likely to represent noise introduced during the encoding process, and therefore  
5                   rejecting said at least one (run, level) pair having a level magnitude of one in order to  
6                   reduce noise.

7

8       28. The decoder as claimed in claim 27, wherein said at least one processor is  
9                   programmed to perform a table lookup using the run length of said at least one (run,  
10                  level) pair having a level magnitude of one and a level magnitude of a (run, level) pair  
11                  immediately following said at least one (run, level) pair having a level magnitude of one  
12                  for determining that said at least one (run, level) pair having a level magnitude of one is  
13                  likely to represent noise introduced during the encoding process.

14

15       29. The decoder as claimed in claim 27, wherein the noise is introduced during the  
16                  encoding process by insertion of (run, level) pairs having a predetermined level value  
17                  having a magnitude of one, and said at least one processor is programmed not to reject  
18                  (run, level) pairs having a level value different from the predetermined level value.

19